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ABSTRACT

Divided into two sections, this publication presents facts about and the characteristics of hydrogen and a bibliography on hydrogen. The first section lists nine facts on what hydrogen is, four on where hydrogen is found, nine on how hydrogen is used, nine on how hydrogen can be used, and 14 on how hydrogen is made. Also included are nine advantages and eight disadvantages of the use of hydrogen as fuel. The bibliography section contains 99 titles of journal articles on hydrogen. The name of the journal and the issue in which the article appeared are given, and the titles are arranged by year of publication (1969 to 1983). The bibliography also lists four books with authors, dates of publication, and publishers; three hydrogen publications with the names and addresses of publishers; and three hydrogen films with the names of publishers/producers. (EM)

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A FEW FACTS ABOUT

HYDROGEN

BY H.R. HINDS, M.A.

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WHAT IS IT?

1. The simplest of all elements - 1 electron around a nucleus of 1 proton.
2. The lightest of all elements - 14 times lighter than air.
3. The most plentiful substance in the Universe. Some scientists believe that all other matter originated with hydrogen. The stuff stars are made of.
4. After oxygen, the most common element on Earth.
5. At room temperature, a flammable gas which is odorless, colorless and tasteless.
6. At a fraction below -259°C (-434°F,) its boiling point, it becomes a liquid.
7. It is a solid below -253°C (-423°F,) which is its melting point.
8. At about 7.4 million lbs. of pressure per square inch and at room temperature, it becomes a dense crystaline substance resembling sugar.
9. By itself, it will not support combustion. It must be burned in the presence of oxygen.

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WHERE IS IT FOUND?

1. Because of its lightness, only traces are found in a free state. Virtually all of it rises to the upper reaches of the atmosphere.
2. It most frequently occurs with oxygen as H_2O (water.) There are 326,000,000 cubic miles of water in the oceans and 510,000,000 tons of hydrogen in every mile. Call it inexhaustable!
3. Next, it most commonly occurs with carbon in hydrocarbons such as oil, coal, natural gas, wood, alcohol, methane, propane, butane, etc.
4. It also combines with nitrogen, sulphur, phosphorus and most metals to form hundreds-of-thousands of compounds - more than any other element.

HOW IS IT USED?

1. Some 42% of the hydrogen manufactured is united with the nitrogen in the air to make ammonia much of which is used in fertilizers.
2. The next largest use, about 38%, is for the refining of petroleum.
3. Over 3 trillion cubic feet of hydrogen is produced presently and over half of that is the United States.
4. It is used in the hydrogenation of vegetable and animal oils.

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5. In the annealing of steel.

6. In the manufacture of plastics and the production of synthetic stones or gems.

7. It is important in the desulfurization of fuel oil.

8. Virtually all utilities use hydrogen to cool their generators.

9. Its use as a rocket fuel made APOLLO and the Space Shuttle possible.

HOW CAN IT BE USED?

1. For every application where fossil fuels (hydrocarbons) are now used.

2. For heating homes, offices and industry. It can replace natural gas for cooking.

3. As an aircraft fuel, it is lighter, cleaner burning and more efficient.

4. As a fuel for automobiles, trucks, buses, trains and ships. Engines will last longer because of the lack of carbon deposits.

5. As a fuel for steam plants which now generate over 90% of our electricity.

6. In a newly developed hydrogen-nickel battery - one which will last 20 years and work with much greater efficiency.

7. Since it can be transported as a solid, liquid or gas, it can be used as an energy carrier for other, more limited forms of energy such as geothermal, solar, ocean currents, tides, waves, windpower or nuclear. Using hydroelectric, it can store energy normally wasted in low demand periods. It can be sent through existing natural gas pipelines.

8. In a small, compact unit called a fuel cell, it can produce electricity and fresh water for a single home or a whole shopping center.

9. It will be essential in the production of oil made from coal or oil shale and the manufacture of synthetic pipeline gas made from coal. One barrel of oil from coal will require 6,500 cu. ft. of hydrogen and to make it into gasoline, another 610 cu. ft. The pipeline gas will require 1,500 cu. ft. of hydrogen for every 1,000 cu. ft. For reference, 6,500 cu. ft. of hydrogen is the energy equivelant of 13.9 gallons of gasoline.

HOW IS IT MADE? - In a variety of ways from a multitude of sources.

1. ELECTROLYSIS - Passing an electric current through water (H_2O) splitting the water into its component parts of hydrogen and oxygen. Conventional methods require about 140 Kw of electricity to produce 1 cubic foot of hydrogen. Research has thus far resulted in more efficient techniques:

   A. Electrolysis using a solid-polymer (plastic-like) as a replacement for the normally liquid electrolyte.

   B. Using the sun's energy to provide the necessary electricity at the electrodes.

C. Electrolysis using powdered coal and water. A method requiring half as much electricity as normal methods.

D. A continuous flow electrolytic cell akin to a fuel cell which decomposes steam or the moisture in ordinary room air.

2. THERMOCHEMICAL DISSOCIATION - Splitting water using various chemicals and heat energy. So far, temperatures of about 1,400°C are required.

3. THERMAL DECOMPOSITION - Splitting water using just heat energy. If done directly, in a one-step process, it requires extremely high heat levels - 2,500° - 3,000°C (4,500° - 5,400°F.) Only special atomic reactors, the sun and perhaps magma are sources of such temperatures.

4. PHOTO DISSOCIATION - Using light energy to split the molecules of high pressure steam.

5. PHOTO CATALYTIC DECOMPOSITION - Using light energy and a catalyst to split water.

6. PHOTOCHEMICAL - The use of an organic molecule with rhodium metal at its core and light energy to split water.

7. PHOTO ENZYME - The use of light energy and an enzyme (a protein-like material) to split water.

8. PHOTO CHLOROPHYLL - An artificial photosynthesis process which sidetracks the hydrogen that would normally combine with carbon to form carbohydrates.

9. THERMAL DISSOCIATION - The use of a permeable membrane to decompose water vapor in superheated steam.

10. NATURAL GAS REFORMING - Produces hydrogen from methane by partial oxidation or reforming with steam. This is the way most hydrogen is produced now for commercial purposes.

11. STEAM REFORMING - Vaporizing hydrocarbons to obtain hydrogen.

12. STEAM REFORMING - Also a method of passing steam over iron or other metals.

13. ORGANIC SOURCES - Hydrogen may be obtained from waste products such as manure, urban refuse, logging or wood residue, agricultural crops and food, industrial wastes and municipal sewage solids.

14. SUMMARY - Virtually any hydrogen compound can be made to release its hydrogen using electricity, heat, light or chemical energy singly or in combination.

WHAT ARE ITS ADVANTAGES?

1. The sources of hydrogen are inexhaustable.

2. It is a renewable fuel. When it is burned, the hydrogen (H) combines with the oxygen (O) to form water (H_2O)

3. It is non-polluting. Since it can be burned in a manner releasing only water vapor there are none of the common pollutants of fossil fuels - carbon dioxide,

carbon monoxide, sulphur dioxide, nitrogen oxide, etc.

4. It is non-toxic. It is harmless to plant or animal life.

5. It is safe. It can only burn in the presence of oxygen. In tanks of gasoline or kerosine, oxygen accumulates more easily allowing for combustion. When it does burn, there is little lateral radiation of heat. The flames go straight up. Things close to it are less likely to catch fire. When hydrogen is stored in the form of a hydride, there is little chance of combustion or explosion even when the container is impacted.

6. It is a storable energy source. It can be stored as a solid, liquid or compressed gas. Hydroelectricity, solar and wind energy, geothermal, etc. cannot be stored.

7. It is transportable. It can be moved from one place to another easily either in tanks or through pipelines. Again, nuclear energy and alternative energy sources cannot be transported.

8. It is more efficient. It burns with a hotter flame than gasoline or natural gas thereby taking less time to provide the heat necessary to cook food or heat a home.

9. It is universal. Since water and hydrogen compounds, even salt water, sewage water and organic waste can be used to make hydrogen and since a variety of energy sources - heat, electricity, chemical and light - can be utilized, it makes this energy source available anywhere in the world.

WHAT ARE ITS DISADVANTAGES?

1. Present cost: $2 - $3 per million BTUs when made from natural gas. Estimated $3 - $5 per million BTUs when made from coal. Other processes, up to $25 per million BTUs. Presently gasoline is $6 - $8 per million BTUs but those figures will rise as the price of oil increases. When a way is found to use the sun's energy, The price of hydrogen will be stable.

2. Embrittlement of some metals with hydrogen contact.

3. Corrosion of materials - true also of other fuels.

4. Oxidation. The natural combining of oxygen with materials. Rust is an example. It happens with hydrogen also - the combining of hydrogen and oxygen to form water. It's a disadvantage because it represents a loss in fuel supply.

5. As a gas it requires a heavy, large volume tank. Some safety precautions.

6. As a liquid there are large losses and a somewhat difficult procedure.

7. In solid form there is large weight and a degeneration of the hydride metal.

8. A large volume/weight to energy ratio which limits the driving range of an automobile. Optimum range at present is about 100-125 miles for a hydrogen hydride system which is preferable to a liquid storage system because of safety.

Additional research will improve some of the aforementioned problems.

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